Description

VIDEO SIGNAL SEPARATING METHOD AND RELATED APPARATUS

BACKGROUND OF INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a video signal separator, and more particularly, to a method and related apparatus for separating a luminance signal from a video signal.

[0003] 2. Description of the Prior Art

[0004] It has been over fifty years since color TVs were introduced to the public. A composite color TV signal (video signal in brief) for a color TV includes luminance as well as chrominance information. A luminance signal of the video signal works with frequencies ranging from 0 (DC) to 5.5 MHz, while a chrominance signal, which is carried by a carrier, works from 3.58 MHz to 4.43 MHz and overlaps the luminance signal. Numerous patents, such asUS4,703,342, US4,954,885, US5,225,899, US5,231,477,

US5,231,478, US5,386,244, US5,416,531, US5,416,532, US5,517,255, and EP0161923A2, have disclosed different methods and apparatus to separate the luminance signal from the video signal.

[0005] Fig.1 is a function block diagram of a video signal separator 10 according to the prior art. The video signal separator 10 is capable of separating an analog video signal into a luminance signal and a chrominance signal. The video signal separator 10 includes an analog/digital converter (ADC) 12 for converting the analog video signal into a digital downward reference video signal DRVS, a first line delay circuit 14 electrically connected to the ADC 12 for delaying the DRVS by one horizontal line (will be described in more details later) so as to generate a target video signal TVS, a second line delay circuit 16 electrically connected to the first line delay circuit 14 for delaying the TVS by one horizontal line so as to generate an upward reference video signal URVS, a horizontal reference chrominance signal generator 18 (HRCS generator) for receiving the DRVS, the TVS and the URVS so as to generate a horizontal reference chrominance signal HRCS, a vertical reference chrominance signal generator 20 (VRCS generator) for receiving the TVS so as to generate a vertical ref-

erence chrominance signal VRCS, a horizontal/vertical reference chrominance signal generator 22 (HVRCS generator) for receiving the DRVS, the TVS and the URVS so as to generate a horizontal/vertical reference chrominance signal HVRCS, a judging device 24 for receiving the DRVS, the TVS and the URVS so as to generate a select signal, a multiplexer 26 for outputting one of three signals HRCS, VRCS and HVRCS by determining the select signal transmitted from the judging device 24, and a subtractor 28 for subtracting signals output by the multiplexer 26 from the TVS so as to generate the luminance signal, and a signal output from the multiplexer 26 being the chrominance signal.

[0006] The ADC 12 samples the analog video signal with a sampling frequency f_s, which is four times a color subcarrier f_{sc}, and generates the DRVS, so chrominance signals of two adjacent sampling points have ninety degrees of phase difference. Since the color subcarrier f_{sc} is equal to $(455/2)fH$, wherein fH is a horizontal scan frequency, which is equal to the amount of horizontal scan lines projected onto a screen 40 per second by a cathode tube of a color TV, chrominance signals of any sampling points on two adjacent horizontal scan lines have 180 degrees of

phase difference. Fig.2 illustrates a phase diagram of chrominance signals of any sampling points of three adjacent horizontal scan lines on screen 40 according to the prior art. A first line 42, a second line 44 and a third line 46 each include five sampling points, and an arrow embraced in a sampling point indicates a phase of the sampling point. For example, three sampling points 48, 50 and 52 are respectively represented by Y+C, Y−C and Y+C, wherein Y represents a luminance signal of a sampling point while C represents a chrominance signal of a sampling point, and chrominance signals of the sampling points 48 (Y+C) and 50 (Y−C) have 180 degrees of phase difference.

[0007] Operations of the video signal separator 10 are described as follows: Please refer to Fig.1 again. When a video signal of an NTSC (National Television Standards Committee) system travels through the ADC 12, the ADC 12 transforms the video signal into the DRVS with the sampling frequency f_s. Then the first line delay circuit 14 delays the DRVS by a horizontal scan line so as to generate the TVS. The second line delay circuit 16 delays the TVS by a horizontal scan line and generates the URVS. The HRCS generator 18, the VRCS generator 20 and the HVRCS generator

22 respectively transform the DRVS, the TVS, and the URVS into the HRCS, the VRCS, and the HVRCS. For example, a transfer function for the HRCS generator 18 can be $Ch(Z)=(-1/4)(1-Z^{-2})^2$, a transfer function for the VRCS generator 20 can be $Cv(Z)=(-1/4)(1-Z^{-L})^2$, and a transfer function for the HVRCS generator 22 can be $Chv(Z)=(-1/4)(1-Z^{-2})^2(-1/4)(1-Z^{-L})^2$, wherein Z^{-1} represents delaying a sampling point while Z^{-L} represents delaying a horizontal scan line. Then the multiplexer 26 determines the select signal transmitted from the judging device 24 and outputs one of the HRVS, the VRCS and the HVRCS. How the judging device 24 generates the select signal is described as follows.

[0008]   Fig.3 illustrates a function block diagram of the judging device 24 according to the prior art. The judging device 24 includes a horizontal luminance signal non-correlated value calculator 60 (HLNC calculator) for calculating a horizontal luminance signal non-correlated value HLNC, a horizontal chrominance signal non-correlated value calculator 62 (HCNC generator) for calculating a horizontal chrominance signal non-correlated value HCNC, a vertical luminance signal non-correlated value calculator 64 (VLNC generator) for calculating a vertical luminance sig-

nal non-correlated value VLNC, and a vertical chrominance signal non-correlated value calculator 66 (VCNC generator) for calculating a vertical chrominance signal non-correlated value VCNC, and a judging circuit 68 for generating the select signal according to the HLNC, the HCNC, the VLNC and the VCNC. The judging circuit 68 determines a smallest non-correlated value among these four non-correlated values and generates the select signal to guide the multiplexer 26 to output the HRVS, the VRCS or the HVRCS according to the smallest non-correlated value. The aforementioned calculator 60, 62, 64 and 66 are all used to calculate non-correlation among a plurality of signals. The non-correlation calculation is well known by those skilled in the art, and a detailed description is omitted here.

[0009] As the judging device 24 generates the select signal, the multiplexer 26 is capable of generating the chrominance signal according to the select signal. Then the subtractor 28 calculates the luminance signal by subtracting the chrominance from the video signal, that is, separating the luminance signal from the video signal.

[0010] The video signal separator 10 of the prior art has at least two drawbacks:

[0011] 1.The judging device 24 of the video signal separator 10 depends on only three video signals (the DRVS, TVS and URVS) to generate the select signal. That the judging device 24 depends on only the TVS and two video signals respectively disposed upward and downward next to the TVS to generate the select signal is likely to generate a non-appropriate select signal and further calculates a false luminance signal and chrominance signal as well. For example, if the differences from the TVS to the upward as well as to the downward video signal are both significantly large while these two differences differs slightly from each other, the VLNC calculator 64 of the judging device 24 calculates a small VLNC and the judging circuit 68 transmits corresponding select signal to the multiplexer 26 according to the small VLNC, misleading the multiplexer 26 to output false luminance signal and chrominance signal.

[0012] 2.The video signal separator 10 of the prior art generates the luminance signal as well as the chrominance signal in a so-called hard decision way--the multiplexer 26 only outputs one of the HRVS, TVS and VRVS as the luminance signal. When the non-correlated values respectively generated by the calculators 60, 62, 64 and 66 differs significantly from one another, the hard decision can calculate a

luminance signal and a chrominance signal both with a tolerable error. However, when the non-correlated values generated by the calculators 60, 62, 64 and 66 are not significantly differ from one another, the select signal output from the judging device 24 by referring to these non-correlated values may mislead the multiplexer 26 to output improper luminance signal and chrominance signal.

SUMMARY OF INVENTION

[0013] It is therefore an objective of the present invention to provide a video signal separator and related apparatus capable of separating a luminance signal from a video signal of a video image displayed on a display device based on five horizontal scan lines to overcome the drawbacks of the prior art.

[0014] In one embodiment, the method includes the following steps: displaying the video image onto the display device in an interlaced way, utilizing a processor to calculate a first factor by determining the video signal and a plurality of first video signals neighboring the video signal, utilizing the processor to calculate a second factor by determining the video signal and at least one second video signal, which also neighbors the video signal but is distinct

from the plurality of the first video signals, and utilizing the processor to determine the luminance signal of the video signal according to the video signal, the plurality of first video signals, the second video signal, the first factor, and the second factor.

[0015] According to the embodiment, the video signal separator is capable of separating a video signal sampled from a composite color TV signal according to a sampling frequency into a luminance signal and a chrominance, the video signal separator including a plurality of delay circuits for generating a target video signal and a plurality of reference video signals by delaying the video signal, an HCS generator for generating an HCS according to the target video signal, an SLFD generator for generating an SLFD according to the target video signal and the plurality of reference video signals, a VCS generator for generating a VCS, a chrominance signal generator for generating the chrominance signal of the video signal by determining the HCS, the VCS, and the SLFD, and a luminance signal generator for generating the luminance signal of the video signal according to the chrominance signal of the video signal and signals output from the plurality of delay circuits. The VCS generator includes a UDFD generator for

generating a UDFD according to the target video signal and the plurality of reference video signals and a VRVS generator for generating a plurality of VRVSs according to the target video signal and the plurality of reference video signals, wherein the VCS corresponds to the UDFD and the plurality of VRVSs.

[0016] It is an advantage of the invention that a video signal separator for separating a luminance signal from a video signal according to differences of a horizontal scan line and another four horizontal scan lines in soft decision can prevent an error that a judging device of the prior art video signal separator makes in determining a select signal from occurring.

[0017] These and other objectives of the claimed invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0018] Fig.1 is a function block diagram of a video signal separator according to the prior art.

[0019] Fig.2 is a phase diagram of chrominance signals of any sampling points of three adjacent horizontal scan lines

according to the prior art.

[0020]   Fig.3 is a function block diagram of a judging device of the video signal separator shown in Fig.1 according to the prior art.

[0021]   Fig.4 is a function block diagram of a video signal separator according to the present invention.

[0022]   Fig.5 is a diagram of a Sigmoid-like curve.

[0023]   Fig.6 is a function block diagram of an HIC of the video signal separator shown in Fig.4 according to the present invention.

[0024]   Fig.7 is a function block diagram of a VIC of the video signal separator shown in Fig.4 according to the present invention.

[0025]   Fig.8 is a function block diagram of intermediate reference signal generators of the video signal separator shown in Fig.4 according to the present invention.

[0026]   Fig.9 is a function block diagram of a UDFD generator of the video signal separator shown in Fig.4 according to the present invention.

DETAILED DESCRIPTION

[0027]   Fig.4 is a function block diagram of a video signal separator 70 according to one embodiment of the present in-

vention. The video signal separator 70 is capable of separating a video signal, like an NTSC signal as well as a PAL (phase alternation by line) signal, into a luminance signal S_c and a chrominance signal S_y. The video signal separator 70 includes an ADC 72 for transferring a video signal into a digital second downward reference video signal S_{dn2}, a first line delay circuit 74 for delaying the S_{dn2} by a horizontal scan line so as to generate a first downward reference video signal S_{dn1}, a second line delay circuit 76 for delaying the S_{dn1} by a horizontal scan line so as to generate a target video signal S_{obj}, a third line delay circuit 78 for delaying the S_{obj} by a horizontal scan line so as to generate a first upward reference video signal S_{up1}, a fourth line delay circuit 80 for delaying the S_{up1} by a horizontal scan line so as to generate a second upward reference video signal S_{up2}, a horizontal chrominance signal generator 82 (HCS generator) for generating a horizontal chrominance signal S_{hc} according to the S_{obj}, a horizontal/vertical fading factor generator 84 (SLFD generator) for generating a horizontal/vertical fading factor SLFD according to the S_{obj} as well as the plurality of reference video signals S_{dn1}, S_{dn2}, S_{up1} and S_{up2}, a vertical chrominance signal generator 92 (VCS generator) for generating

a vertical chrominance signal S_{vc}, a chrominance signal generator 98 (CS generator) for generating the S_c according to the S_{hc}, the S_{vc}, the SLFD and an equation 1 S_c =SLFD*S_{hc}+(1−SLFD)*S_{vc}, and a luminance signal generator 100 (LS generator) for generating the S_y by subtracting the S_c from the S_{obj}.

[0028] How the SLFD generator 84 generates the SLFD is described as follows: Please refer to Fig.4 again. The SLFD generator 84 of the video signal separator 70 includes a horizontal interference calculator 86 (HIC) for calculating a horizontal chrominance interfering factor D_{hc} as well as a horizontal luminance interfering factor D_{hy} according to the reference signals S_{dn1}, $S_{dn\ 2}$, S_{up1} and S_{up2}, a horizontal difference generator 87 (H_{diff} generator) for generating a horizontal difference H_{diff} according to the D_{hc} as well as the D_{hy}, a vertical interference calculator 88 (VIC) for calculating a vertical chrominance interfering factor D_{vc} as well as a vertical luminance interfering factor D_{vy} according to the reference signals S_{dn1}, $S_{dn\ 2}$, S_{up1} and S_{up2}, a vertical difference generator 89 (V_{diff} generator) for generating a vertical difference V_{diff} according to the D_{vc} as well as the D_{vy}, and an SLFD module 90 for generating the SLFD according to the H_{diff}, the V_{diff} and an equation 2

SLFD=Lim($k*V_{diff}-H_{diff}$), wherein k is a weighing factor and Lim() is a Sigmoid-like curve.

[0029] Fig.5 illustrates a diagram of the Sigmoid-like curve in this embodiment. As shown in Fig.5, when $k*V_{diff}-H_{diff}$ is greater or less than a tolerance of error D, the video signal separator 70 is not different from the video signal separator 10 of the prior art. When $k*V_{diff}-H_{diff}$ falls into a region from +D to D, the video signal separator 70 of the present invention generates the S_c as well as the S_y by determining an SLFD mapped on the Sigmoid-like curve by $k*V_{diff}-H_{diff}$. In essence, this embodiment generates S_c and S_y in a so-called soft decision instead of the hard decision. The SLFD can be treated as a weighing factor for the calculations between S_{hc} and S_{vc} to generate S_c and S_y. In other words, if $k*V_{diff}$ is less than H_{diff} by D, this indicating that a difference between the vertical samples multiplied by k is much less than a difference between the horizontal samples , the video signal separator 70 therefore generates the S_c and the S_y according to the S_{vc}; on the contrary, if $k*V_{diff}$ is greater than H_{diff} by D, the video signal separator 70 generates the S_c and the S_y according to the S_{hc} The H_{diff} generator 87 of the SLDF generator 84 refers to an equation 3 $H_{diff}=a*D_{hy}+(1-a)*D_{hc}$ to calculate H_{diff}

while the V_{diff} generator 89 of the SLDF generator 84

refers to an equation 4 $V_{diff}=b*D_{vy}+(1-a)*D_{vc}$ to calculate

V_{diff}. An a in the equation 3 and a b in the equation 4 are

both weighing factors and can be modified according to

the video signal or to a TV system from which the video

signal comes.

[0030] The process to generate D_{hc}, D_{hy}, D_{vc} and D_{vy} is described

as follows: Please refer to Fig.6 and Fig.7. Fig.6 is a circuit

diagram of the HIC 86. Fig.7 is a circuit diagram of the VIC

88. The HIC 86 includes a first adder 110 for generating a

first vertical luminance interfering signal V_{y1} by adding

the S_{up1} to the S_{obj}, a first 1-D comb filter 112 for trans-

ferring the V_{y1} into a first vertical luminance filtered signal

V_{fy1}, a second adder 114 for generating a second vertical

luminance interfering signal V_{y2} by adding the S_{dn1} to the

S_{obj}, a second 1-D comb filter 116 for transferring the V_{y2}

into a second vertical luminance filtered signal V_{fy2}, a

third adder 118 for generating a vertical luminance signal

S_{vy} by adding the V_{fy2} to the v_{fy1}, a first absoluter 120 for

transferring the S_{vy} into a positive vertical luminance sig-

nal S_{pvy}, a first low pass filter 122 for transferring the S_{pvy}

into the D_{hy}, a sample point delay circuit 124 for generat-

ing a rightward reference video signal S_{rref} by delaying the

S_{obj} by two sampling points, a subtractor 126 for generating a horizontal chrominance interfering signal H_c by subtracting the S_{rref} from the S_{obj}, a 2-D comb filter 128 for transferring the H_c into a horizontal chrominance filtered signal H_{fc}, a second absoluter 130 for transferring the H_{fc} into a positive horizontal chrominance signal S_{phc}, and a second low pass filter 132 for transferring the S_{phc} into the D_{hc}.

[0031] The VIC 88 includes a first subtractor 150 for generating a first vertical chrominance interfering signal V_{c1} by subtracting the S_{up1} from the S_{obj}, a second subtractor 152 for generating a second vertical chrominance interfering signal V_{c2} by subtracting the S_{dn1} from the S_{obj}, a third subtractor 154 for generating a vertical chrominance signal S_{vc} by subtracting the V_{c1} from the V_{c2}, a third absoluter 156 for transferring the S_{vc} into a positive vertical chrominance signal S_{pvc}, a third low pass filter 158 for transferring the S_{pvc} into the D_{vc}, a first sample point delay circuit 160 (first 2D) for generating a first rightward reference video signal S_{r1ref} by delaying the S_{up1} by two sampling points, a fourth adder 162 for generating a first luminance interfering signal H_{y1} by adding the S_{up1} to the S_{r1ref}, a second sample point delay circuit 164 (second 2D)

for generating a second rightward reference video signal S_{r2ref} by delaying the S_{dn1} by two sampling points, a fifth adder 166 for generating a second horizontal luminance interfering signal H_{y2} by adding the S_{dn1} to the S_{r2ref}, a fourth subtractor 168 for generating a horizontal luminance signal S_{hy} by subtracting the H_{y1} from the H_{y2}, a fourth absoluter 170 for transferring the S_{hy} into a positive horizontal luminance signal S_{phy}, and a fourth low pass filter 172 for transferring the S_{phy} into the D_{vy}.

[0032] How the VCS generator 92 generates the S_{vc} is described as follows: The VCS generator 92 includes a intermediate video signal generator 93 (IVS generator) for generating a plurality of intermediate video signals according to the S_{obj} and the S_{dn1}, $S_{dn\ 2}$, S_{up1} and S_{up2}, an up/down fading factor generator 94 (UDFD generator) for calculating an UP/down fading factor UDFD according the plurality of intermediate video signals, and a vertical reference video signal generator 96 (VRVS generator) for generating the S_{vc} according to the UDFD and the plurality of intermediate video signals.

[0033] How the IVS generator 93 of the VCS generator 92 generates the plurality of intermediate video signals is described as follows: Please refer to Fig.8, which is a func-

tion block diagram of the IVS generator 93 according to the present invention. The IVS generator 93 includes a first upward video signal generator 180 for generating a first upward video signal S_{sup1} according to the S_{obj} and the S_{up1}, a second upward video signal generator 182 for generating a second upward video signal S_{sup2} according to the S_{up1} and the S_{up2}, a first downward video signal generator 184 for generating a first downward video signal S_{sdn1} according to the S_{obj} and the S_{dn1}, and a second downward video signal generator 186 for generating a second downward video signal S_{sdn2} according to the S_{dn1} and the S_{dn2}.

[0034] Video signal generators 180, 182, 184 and 186 of the IVS generator 93 respectively include an adder 188, a multiplier 190, a subtractor 192 and a demodulator 194. The plurality of intermediate video signals S_{sup1}, S_{sup2}, S_{sdn1} and S_{sdn2} each includes a video luminance signal, a first chrominance signal heading to a first direction, and a second chrominance signal heading to a second direction, which is not parallel but usually perpendicular to the first direction.

[0035] How the plurality of video generators 180, 182, 184 and 186 generate a video luminance signal Y_{cu}, a video first

chrominance signal U_{cu} and a video second chrominance signal V_{cu}, all shown in Fig.8, is described as follows: Cite the first upward video signal generator 180 as an example. The Y_{cu} is an arithmetic mean of the S_{up1} and the S_{obj}. The U_{cu} and the V_{cu} are both demodulated from the demodulator 194 by demodulating a signal generated by subtracting the Y_{cu} from the S_{obj}. The demodulator 194 demodulates the Y_{cu} based on the carrier (mentioned in prior art).

[0036] How the UDFD generator 94 of the VCS generator 92 generates the UDFD is described as follows: Fig.9 is a function block diagram of the UDFD generator 94 according to the embodiment. The UDFD generator 94 includes an upward difference generator 97 for generating an upward difference $Diff_{up}$ according to the S_{sup1} and the S_{sup2}, a downward difference generator 95 for generating a downward difference $Diff_{dn}$ according to the S_{sdn1} and the S_{sdn2}, and an upward/downward difference module 99 for generating the UDFD according to the $Diff_{up}$ and the $Diff_{dn}$. The UDFD, the $Diff_{up}$ and the $Diff_{dn}$ obey an equation 5 –
$UDFD = Lim(Diff_{dn} - Diff_{up})$, wherein $Diff_{up} = ABS(Y_u - Y_{cu}) + sqrt((U_u - U_{cu})^2 + (V_u - Vcu)^2)$, wherein $ABS(x)$ represents an absolute value of x, and $sqrt(y)$ is a square root of y.

[0037] In contrast to the prior art, the present invention can provide a video signal separator, which is capable of calculating differences between a video signal located on a horizontal scan line and another four horizontal scan lines, and of then calculating a luminance signal and a chrominance signal of the video signal in soft decision based on the differences and these five horizontal scan lines, for preventing an error the judging device 24 of the prior art video signal separator 10 makes in determining the select signal from occurring. Additionally, the weighing factors k, a and b in equation 1, 2 and 3 can be selectively modified to adapt to a video signal and a TV system in which the video system stays as well.

[0038] Following the detailed description of the present invention above, those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.